Groundwater use and its consequences in Wisconsin

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Where's the water?

All groundwater use has consequences

- What are the consequences of groundwater use in Wisconsin?
  - Drawdown – lowering water levels
  - Alteration of groundwater flow paths
  - Effects on surface water
  - Effects on water quality

Outline – where we're going…

- Aquifers of Wisconsin
- Groundwater use in Wisconsin
  - where?
  - how much?

Outline – where we're going…

- Impacts of this use
  - Water levels
  - Flow directions
  - Water quality
- Trouble spots
  - Dane County
  - Fox Valley
  - SE Wisconsin

Wisconsin's Bedrock Aquifers

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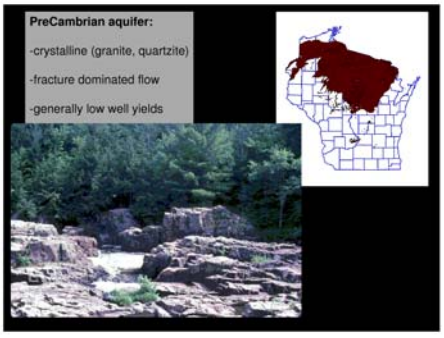

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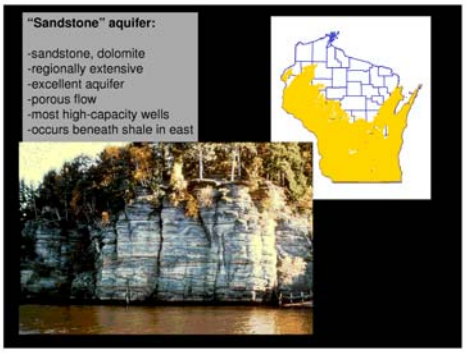
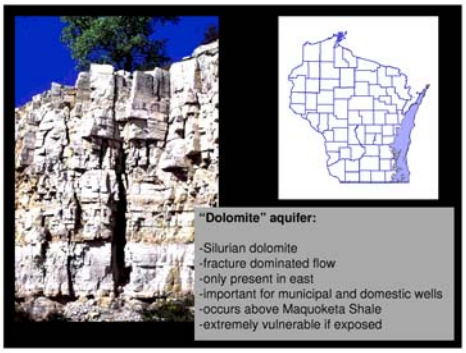
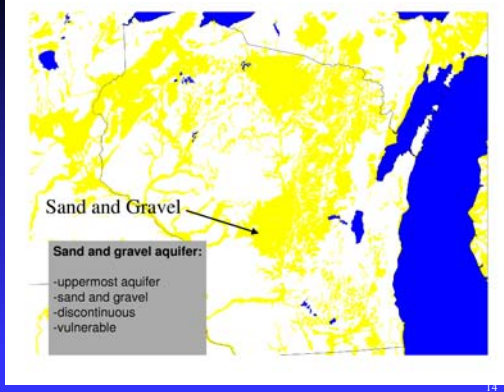
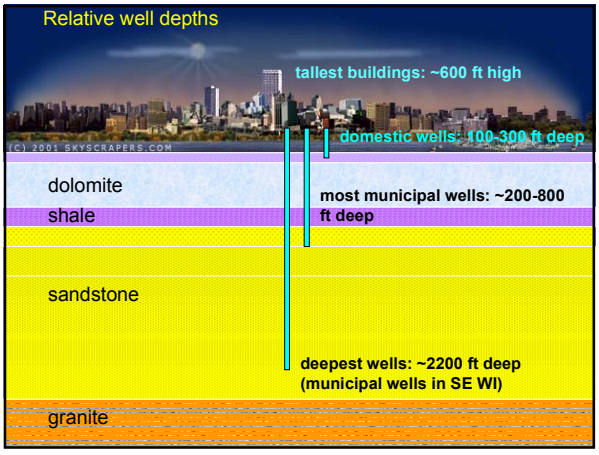




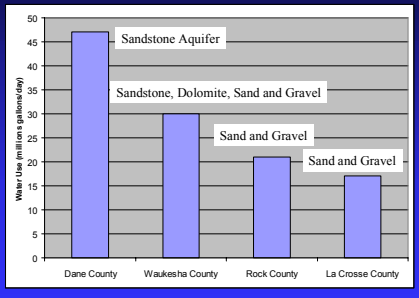
Glacial Geology



Relative well depths



Municipal Groundwater Use – 314 million gallons per day

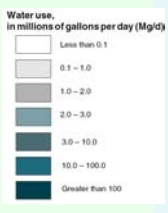


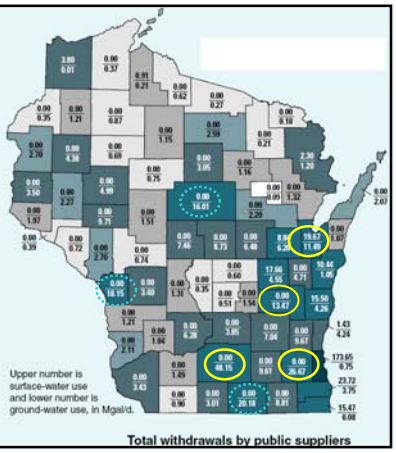
Where are we using groundwater?

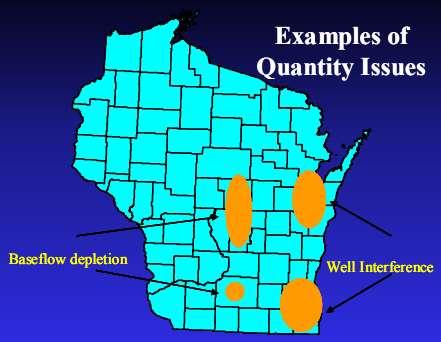
Groundwater use over 10 MGD

bedrock

sand and gravel







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Managing Groundwater

- Reduced Groundwater Flows to Surface Waters

- Excessive Drawdowns – Higher pumping costs and Dry Wells

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What influences the amount of drawdown? Why is there more drawdown in some places than others?

- Well density and well interference
- Pumping rates
- Hydrogeologic setting of the aquifer
  - Transmissivity
    - *Aquifer thickness x hydraulic conductivity*
  - Confined or unconfined settings
    - *Confined aquifers – low storage*
    - *Unconfined aquifers – higher storage*
  - Recharge rates
    - *How rapidly the aquifer is replenished – shallow aquifers generally replenished faster than deep aquifers*

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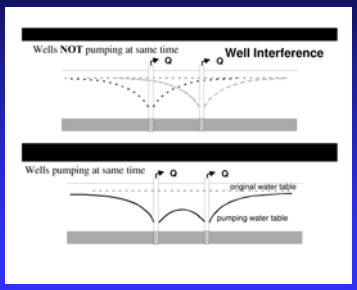
What do water levels look like around a pumping well?



Drawdown reduces well yield

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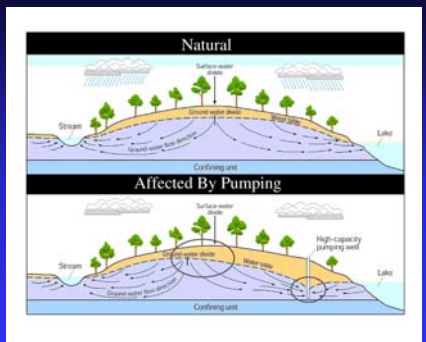
Why is baseflow reduced?



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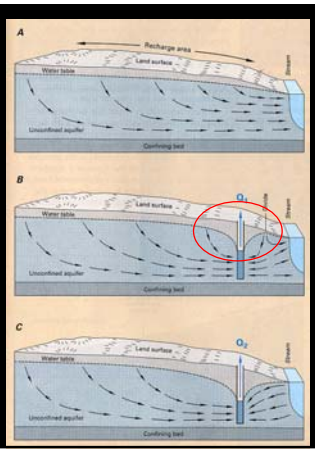
Pumping wells affect groundwater movement

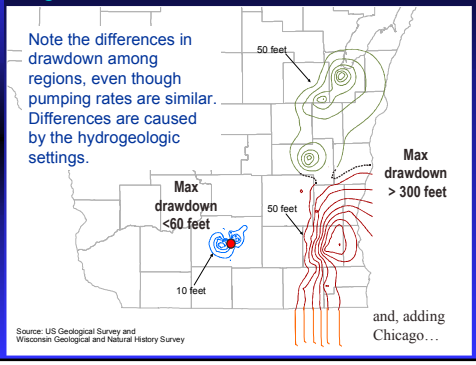
The well causes a cone of depression

Well pumping can reduce flow to surface water



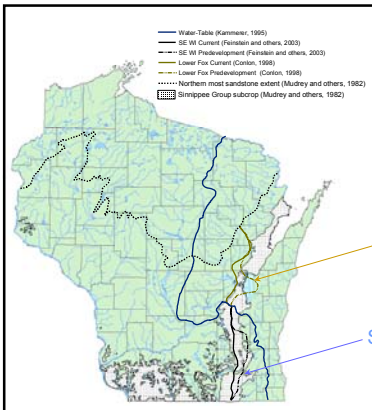
How bad is the problem?
Regional declines in water levels:

Note the differences in drawdown among regions, even though pumping rates are similar. Differences are caused by the hydrogeologic settings.



Source: US Geological Survey and Wisconsin Geological and Natural History Survey

and, adding Chicago…



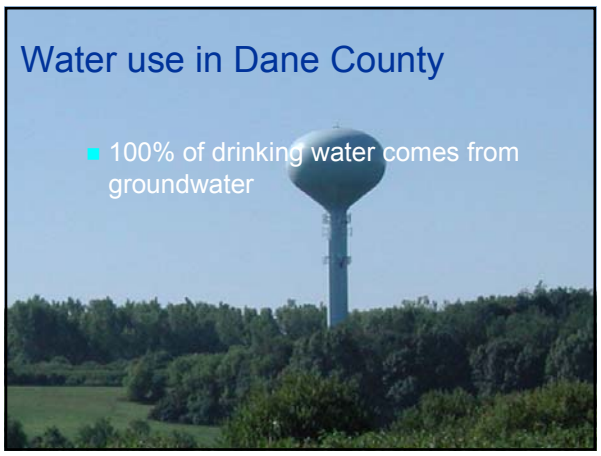
Water use has moved potentiometric divides

Lower Fox Valley

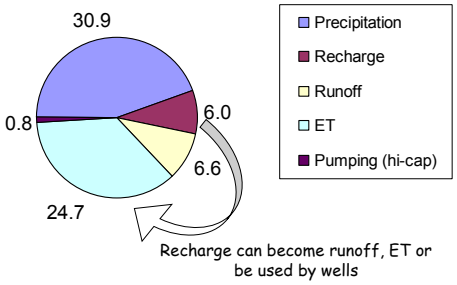
SE Wisconsin

Water use in Dane County

- 100% of drinking water comes from groundwater

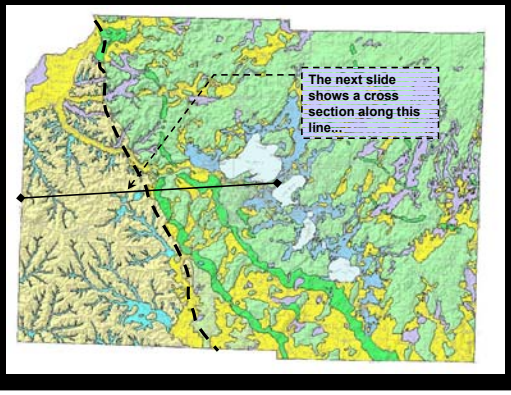


Dane County water budget, inches per year



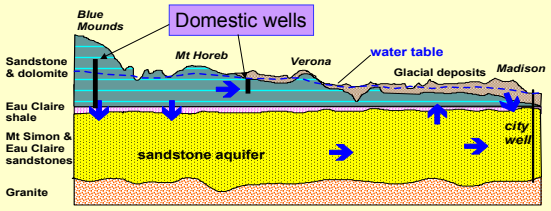
Recharge can become runoff, ET or be used by wells

Dane County geology...

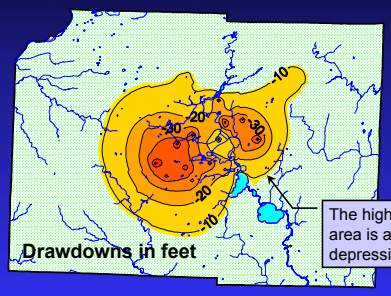


Groundwater moves downward and laterally through Dane County's aquifers...

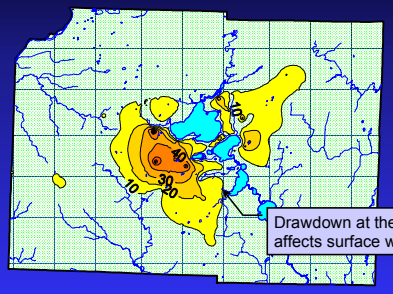
Hydrogeologic Cross Section



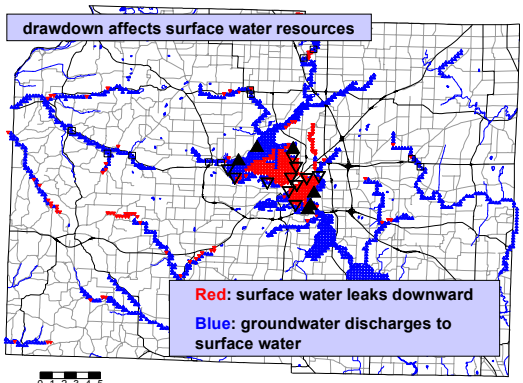
Municipal water use in the Madison area causes significant drawdown, or lowering of water levels, in the deep sandstone aquifer...



Drawdowns in the deep aquifer can affect the water table…reducing flow in streams and water levels in wetlands



Groundwater discharge to lakes and streams

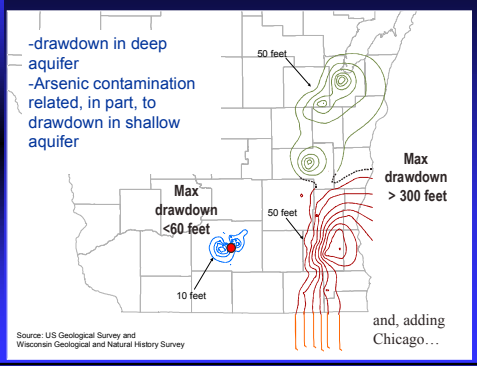


Groundwater discharge in the Nine Springs area

Summary – Dane County

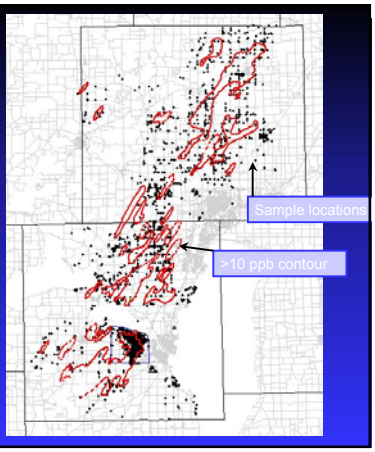
- In Dane County, we pump about 50 MGD from the sandstone aquifer
- There is a regional cone of depression and well interference
- Maximum drawdown about 70 ft
- Visible/measurable impacts on surface water
- Some water quality degradation due to induced recharge

Fox Valley issues



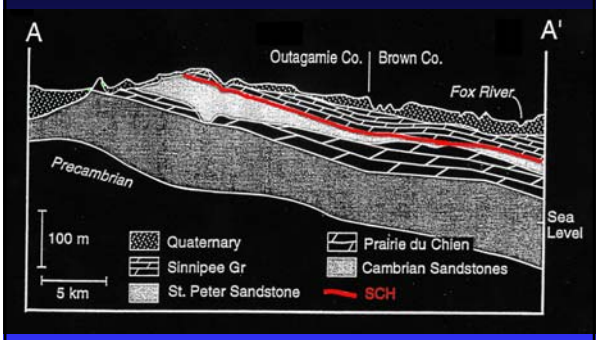
and, adding Chicago…

Arsenic problem areas, Outagamie and Winnebago Counties

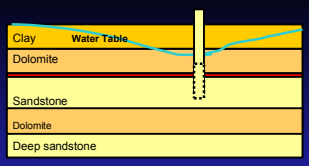


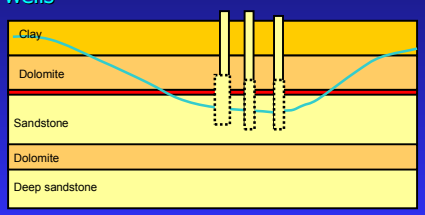
From town-based sampling program, 2000

Fox River valley geology



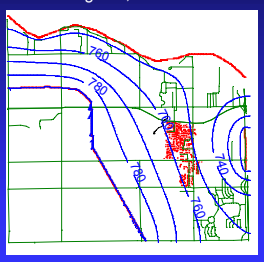
Water levels decline in residential developments with many shallow wells



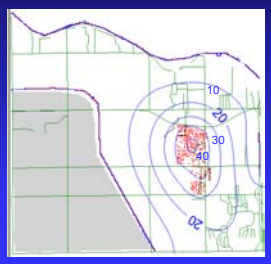


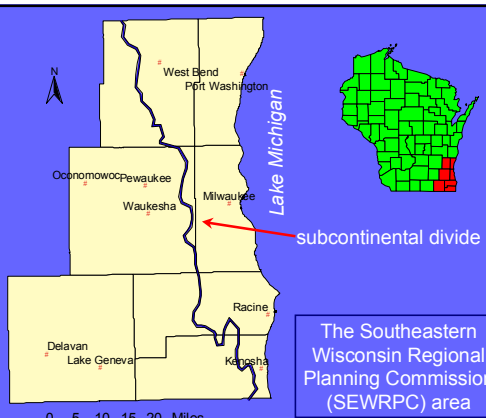
Model calculates draw down caused by many shallow wells

Town of Algoma; 1993 water levels



Simulated drawdown (ft) 467 wells at 300 gpd each

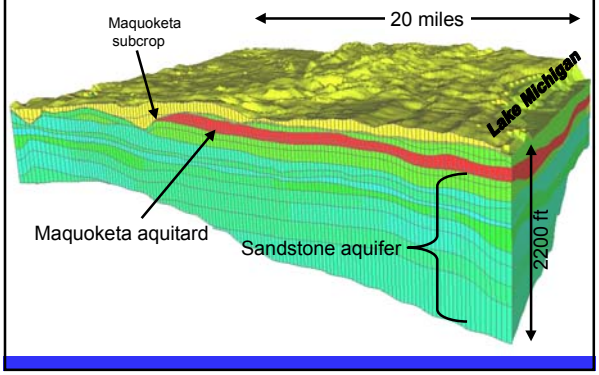




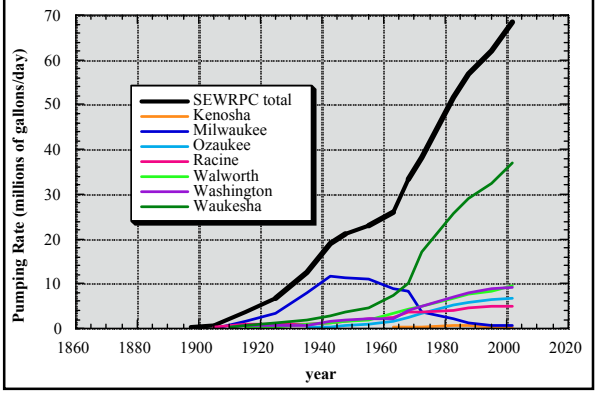
Groundwater issues in Southeast Wisconsin

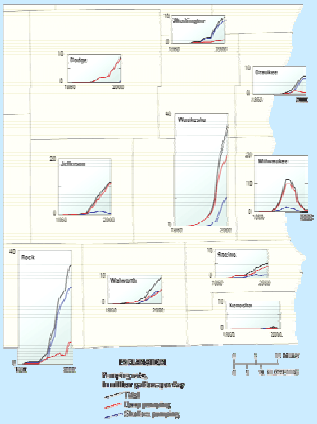
- Groundwater levels are declining (400-800 feet)
- Increasing groundwater demand
- Declining water quality (salinity, TDS, radium)
- Great Lakes water is off limits outside topographic basin

General hydrostratigraphy of southeast Wisconsin

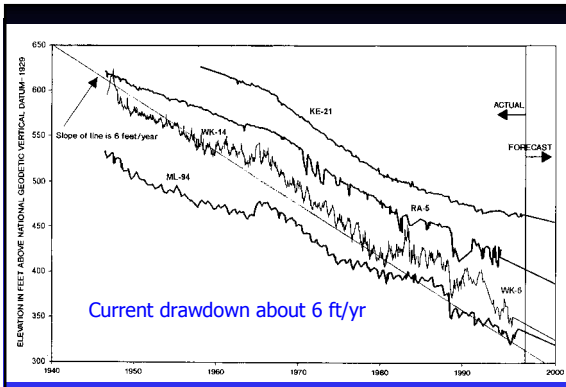


Water use: SE Wisconsin

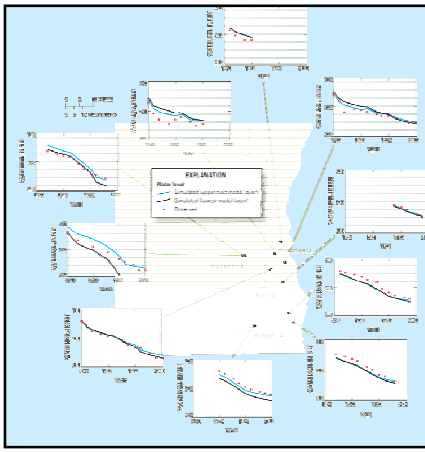




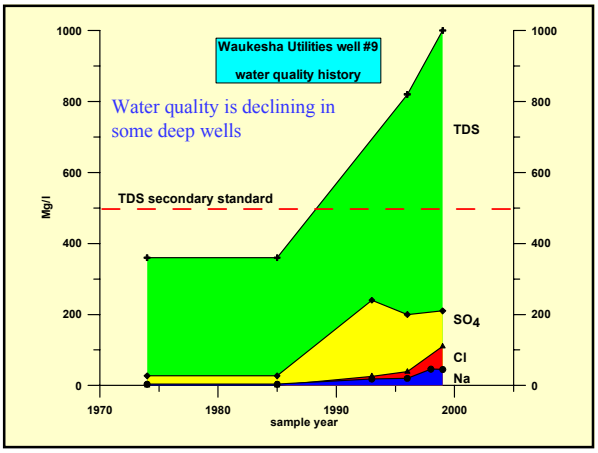
Groundwater use by county



Water levels in SE Wisconsin

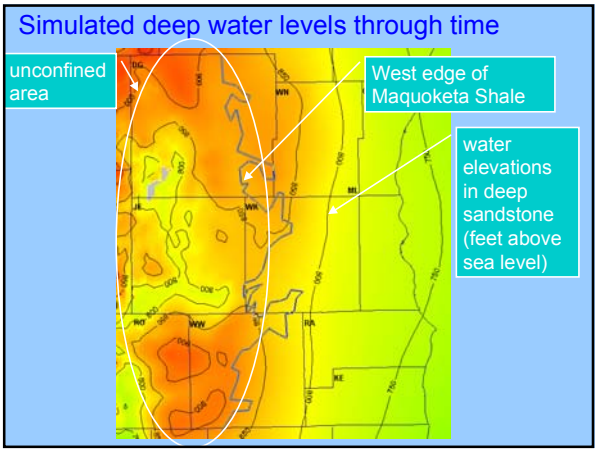


Water-level decline by county

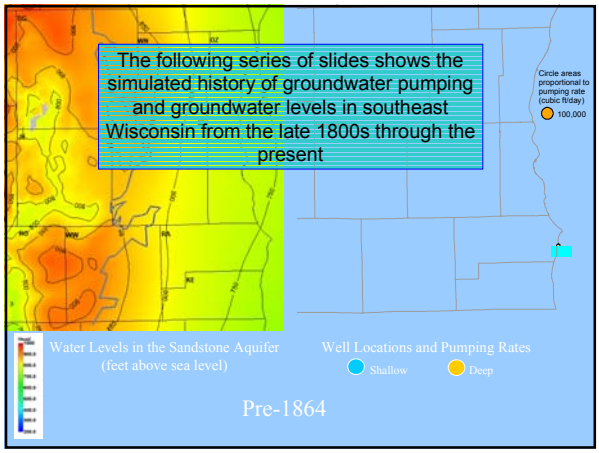


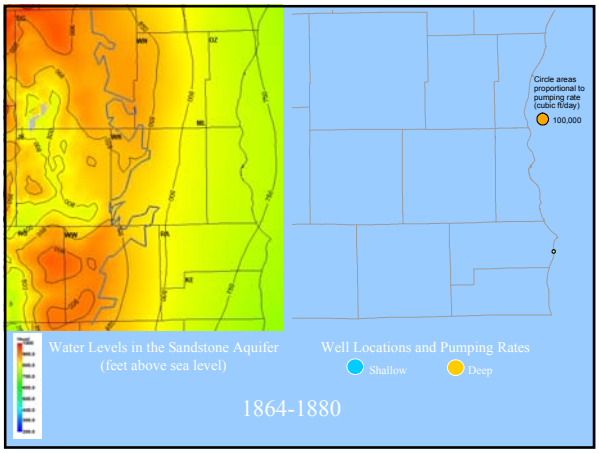
Water Levels in the Sandstone Aquifer in SE Wisconsin from 1862 to 2002 – results of model simulation

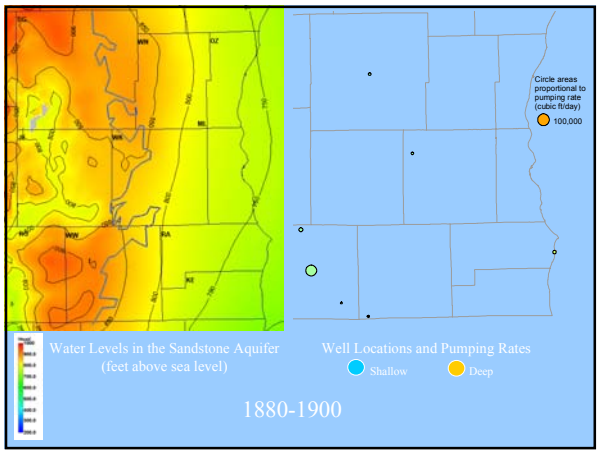
Simulated deep water levels through time

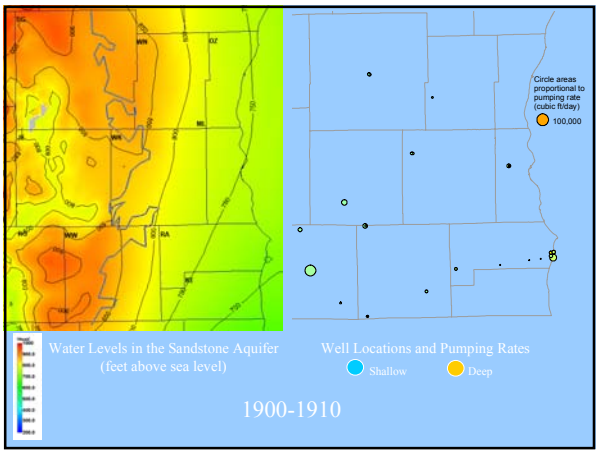


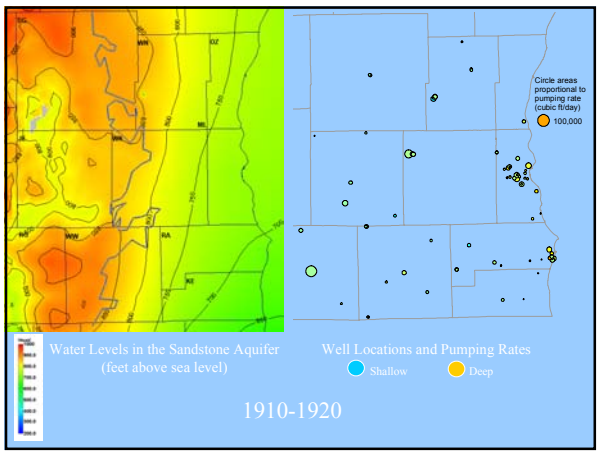
The following series of slides shows the simulated history of groundwater pumping and groundwater levels in southeast Wisconsin from the late 1800s through the present

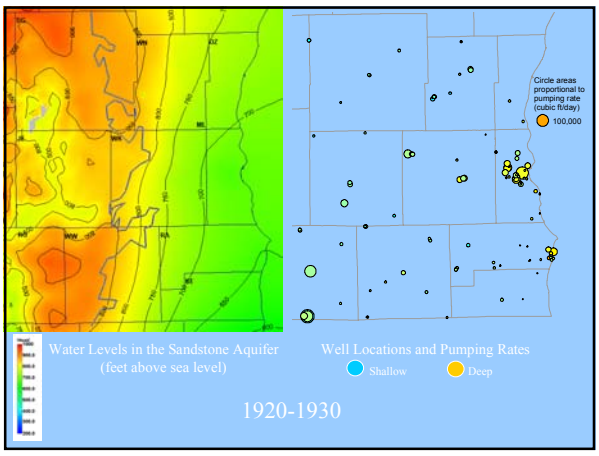


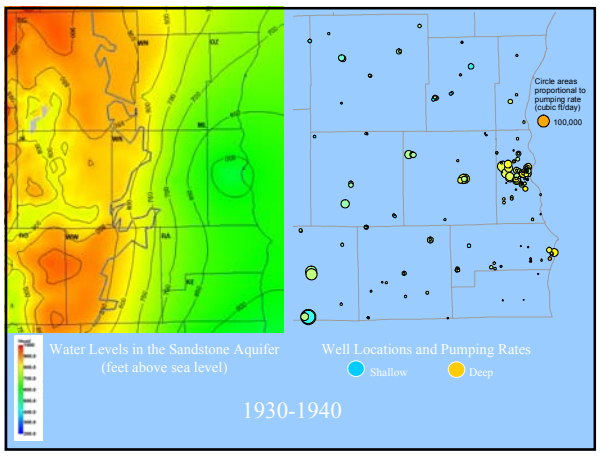


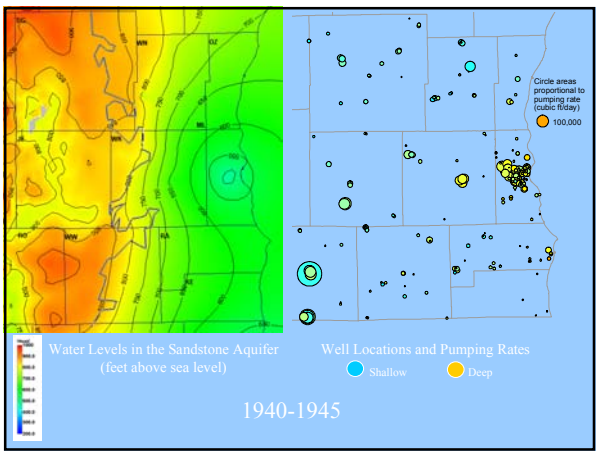


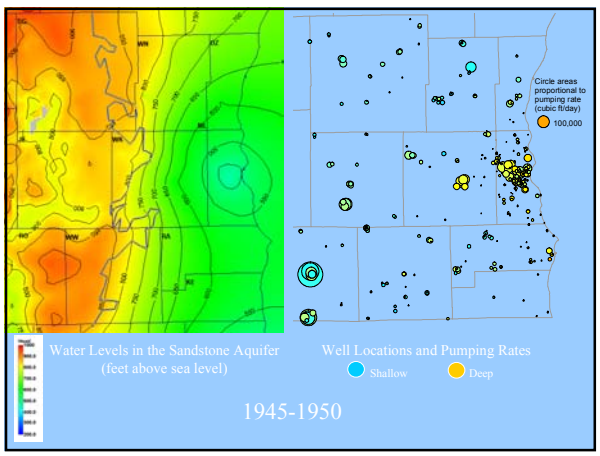


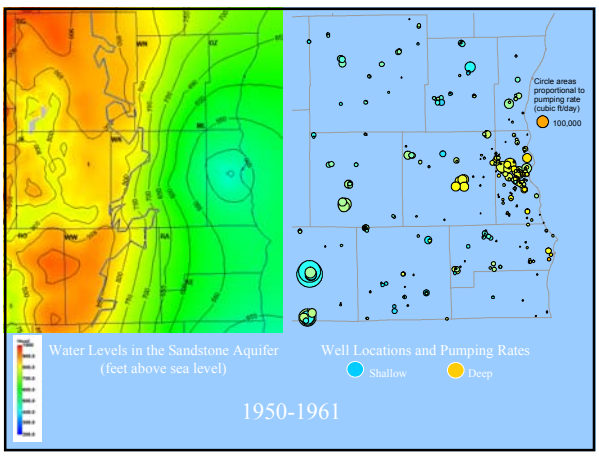

Water Levels in the Sandstone Aquifer
(feet above sea level)
Well Locations and Pumping Rates
Shallow
Deep
Circle areas proportional to pumping rate (cubic ft/day)
100,000
1910-1920

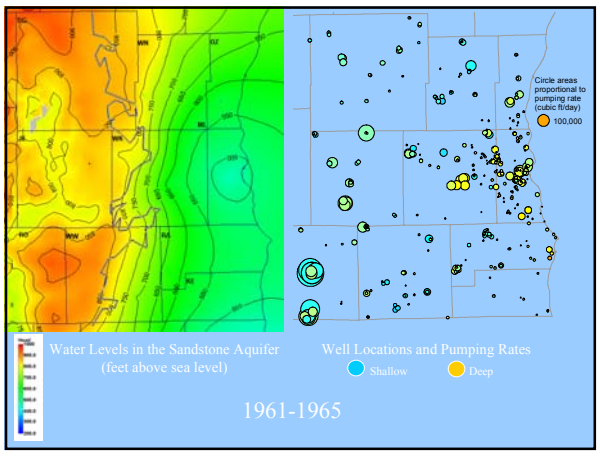

Water Levels in the Sandstone Aquifer
(feet above sea level)
Well Locations and Pumping Rates
Shallow
Deep
Circle areas proportional to pumping rate (cubic ft/day)
100,000
1920-1930

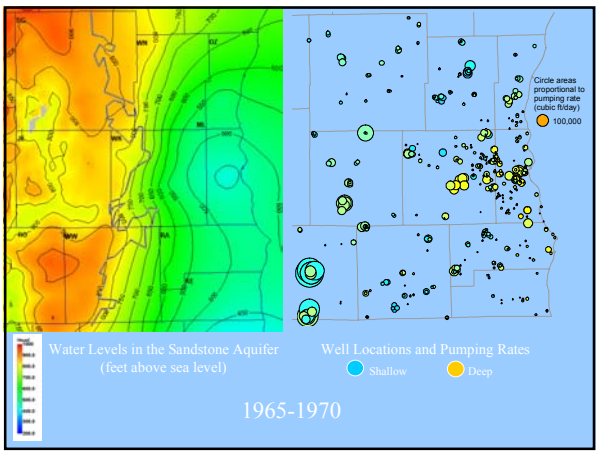

Water Levels in the Sandstone Aquifer
(feet above sea level)
Well Locations and Pumping Rates
Shallow
Deep
Circle areas proportional to pumping rate (cubic ft/day)
100,000
1930-1940

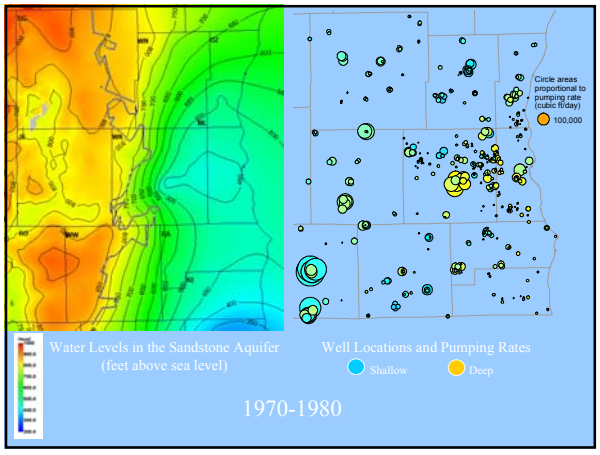

Water Levels in the Sandstone Aquifer
(feet above sea level)
Well Locations and Pumping Rates
Shallow
Deep
Circle areas proportional to pumping rate (cubic ft/day)
100,000
1940-1945

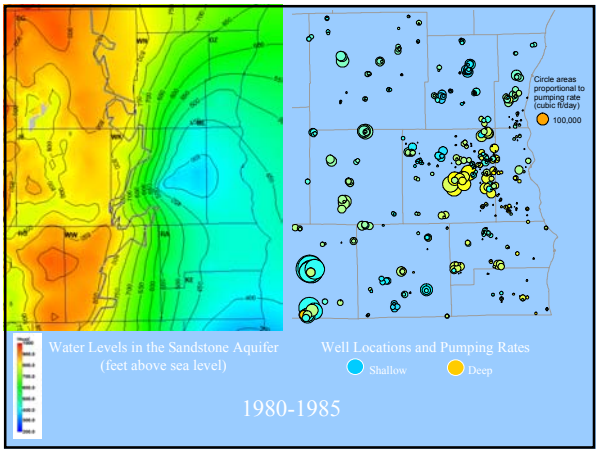

Water Levels in the Sandstone Aquifer
(feet above sea level)
Well Locations and Pumping Rates
Shallow
Deep
Circle areas proportional to pumping rate (cubic ft/day)
100,000
1945-1950

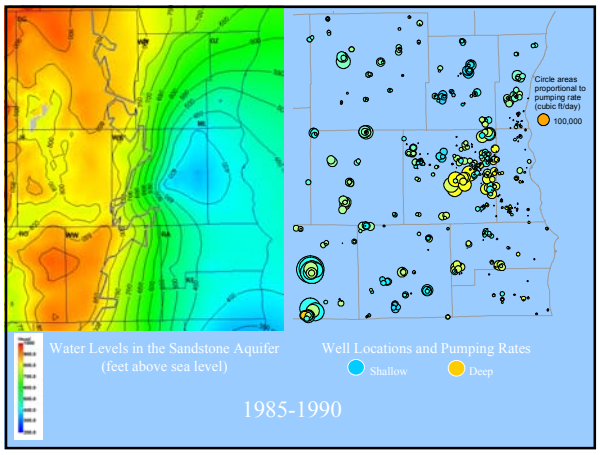

Water Levels in the Sandstone Aquifer
(feet above sea level)
Well Locations and Pumping Rates
Shallow
Deep
Circle areas proportional to pumping rate (cubic ft/day)
100,000
1950-1961

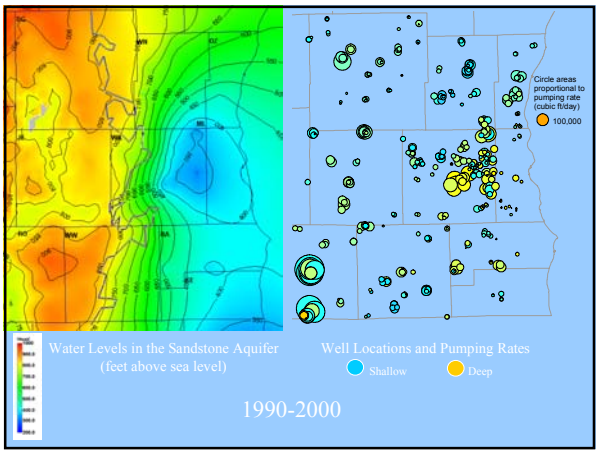

Circle areas proportional to pumping rate (cubic ft/day)
100,000
Water Levels in the Sandstone Aquifer (feet above sea level)
Well Locations and Pumping Rates
Shallow
Deep
1961-1965


Circle areas proportional to pumping rate (cubic ft/day)
100,000
Water Levels in the Sandstone Aquifer (feet above sea level)
Well Locations and Pumping Rates
Shallow
Deep
1965-1970


Circle areas proportional to pumping rate (cubic ft/day)
100,000
Water Levels in the Sandstone Aquifer (feet above sea level)
Well Locations and Pumping Rates
Shallow
Deep
1970-1980


Circle areas proportional to pumping rate (cubic ft/day)
100,000
Water Levels in the Sandstone Aquifer (feet above sea level)
Well Locations and Pumping Rates
Shallow
Deep
1980-1985


Circle areas proportional to pumping rate (cubic ft/day)
100,000
Water Levels in the Sandstone Aquifer (feet above sea level)
Well Locations and Pumping Rates
Shallow
Deep
1985-1990


Circle areas proportional to pumping rate (cubic ft/day)
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Water Levels in the Sandstone Aquifer (feet above sea level)
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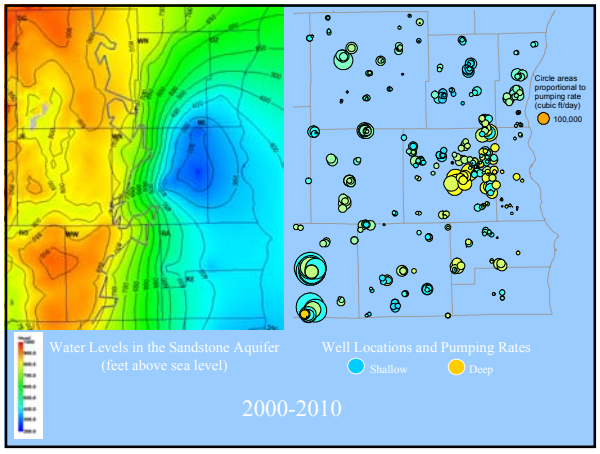
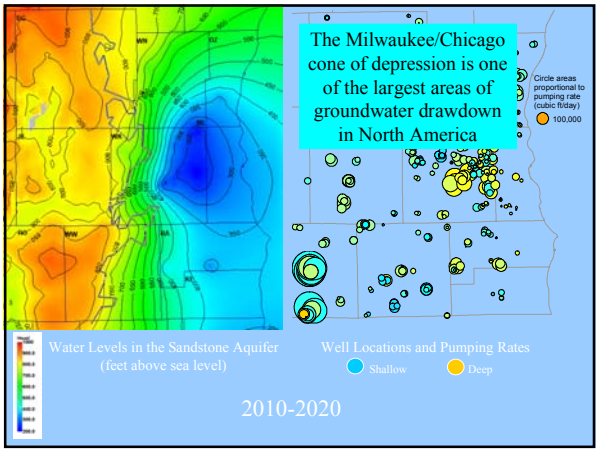
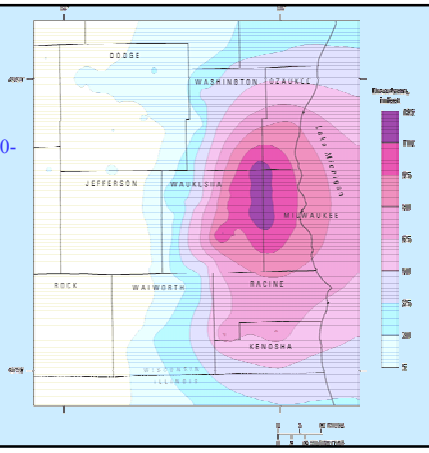




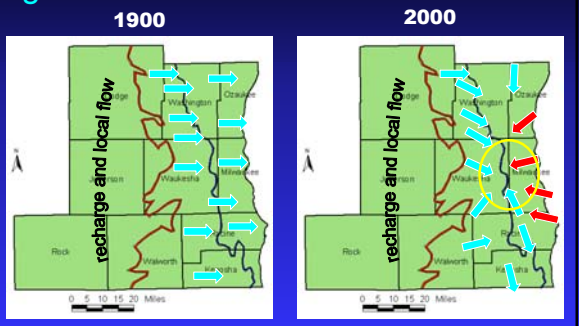
Additional drawdown, 2000-2020

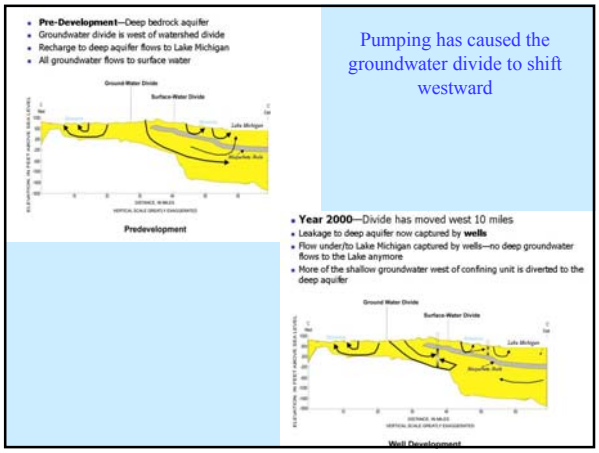


Effects of pumping:

- Pumping from the sandstone aquifer has reversed the direction of flow in the deep part of the flow system below the Lake Michigan coastline.
- From 1864 to 2000, pumping caused a 7% reduction of direct and indirect discharge of shallow groundwater to Lake Michigan.

Pumping has altered groundwater flow directions





Consequences of development…

- Downward flow to sandstone aquifer from above (lakes, streams, and recharge) has increased by 18.3 mgd
- Flow to Lake Michigan has reversed in some places; the total change in L. Michigan flows is 6.9 mgd
- Wisconsin loses about 2.5 mgd to N. Illinois

Summary – SE Wisconsin

- In SE Wisconsin, we pump about 50 MGD from the sandstone aquifer
- There is a regional cone of depression and well interference
- Maximum drawdown about 500 ft
- Few measurable impacts on surface water
- Major alteration of groundwater flow directions
- Some water quality degradation due to upconing of older water

Conclusions

- Wisconsin has wonderful aquifers!
- All water comes from somewhere…you can't get water without consequences somewhere else
- Consequences include
  - Drawdown
  - Reduced aquifer yield
  - Higher pumping/energy costs
  - Reduced flows to surface water
  - Possible water quality impacts

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